ISSN (print) 0093-4666 © 2012. Mycotaxon, Ltd. ISSN (online) 2154-8889

MYCOTAXON

http://dx.doi.org/10.5248/120.23

Volume 120, pp. 23–33 *April–June 2012*

The lichen genus *Chapsa* (*Graphidaceae*) in India

Santosh Joshi, Dalip K. Upreti* & Sanjeeva Nayaka

Lichenology Laboratory, CSIR-National Botanical Research Institute
Rana Pratap Marg, Lucknow – 226 001, India
Correspondence to *: *upretidk@rediffmail.com*

Abstract — This paper provides a detailed account of the 16 species of *Chapsa* recorded in India. *Chapsa patens* and *C. platycarpella* are new records for the Indian lichen biota.

Key words — thelotremoid, distribution, identification key, Western Ghats

Introduction

Until recently the thelotremataceous lichen biota was limited in India to *Chroodiscus*, *Diploschistes*, *Leptotrema*, *Myriotrema*, *Ocellularia*, and *Thelotrema* (Awasthi 1991, 2000). Based on recent revisions (Frisch et al. 2006, Mangold et al. 2009, Rivas Plata et al. 2010), Singh & Sinha (2010) cited 130 taxa representing 13 genera in the *Thelotremataceae* Stizenb. for India. However, recent phylogenetic studies show that taxa previously classified in *Thelotremataceae* do not form a separate lineage but are nested within *Graphidaceae.* The *Graphidaceae,* containing the now-synonymous *Thelotremataceae* (Mangold et al. 2008), comprises the largest lichen family in India, where it is represented by 428 species and 35 genera.

Massalongo introduced *Chapsa* in 1860, a genus resurrected recently by Frisch et al. (2006) to incorporate species earlier classified in *Thelotrema*, *Chroodiscus*, *Ocellularia*, and *Myriotrema*. *Chapsa* is characterized by a thin, corticolous, endoperidermal to epiperidermal thallus, chroodiscoid ascomata with a fused to ± free proper exciple, and periphysoids (Mangold et al. 2009). The closely related or similar *Acanthotrema*, *Chroodiscus*, and *Reimnitzia* differ mainly in spiny paraphysis tips, lack of periphysoids, and isidiate thallus with columnar crystalline layer, respectively. Moreover, *Chroodiscus* is typically foliicolous. *Thelotrema* and *Topeliopsis* differ mainly by lacking distinctly chroodiscoid ascomata. However, several species belonging to the last two genera require further investigation for proper delimitation and placement.

Due to their selective and preferred habitat, most members of thelotremoid *Graphidaceae* are restricted to lower altitudes in tropical to subtropical regions and thus inadequately understood (Hale 1974, 1978, 1981). As a group, thelotremoid lichens represent a significant component of corticolous rainforest microlichen biota, with some extending into temperate regimes (Santesson 1952; Sipman & Harris 1989; Rivas Plata et al. 2008; Purvis et al. 1995). *Chapsa* is pantropical or subtropical but rarely temperate. Generally, it occurs below 1000 m and favors shaded microhabitats in rather disturbed old growth secondary forests (Rivas Plata et al. 2008). *Chapsa* flourishes in the southern and eastern regions of India, with some species found at altitudes of more than 2000 m. The dense moist rain forests of the eastern Himalayas and the evergreen forests of Western Ghats provide a suitable habitat for its growth. Most species of *Chapsa* grow on rough bark, thus indicating a particular type of forest community predominant in moist humid regions. The species generally acquire the same colour pattern as the substratum so that in the field many are difficult to distinguish from bark. The tree bark characteristics appear to influence the distribution patterns of the taxa in tree communities. Lichens growing on striate bark concentrate in deep furrows, with their ascomata emerging from cracks, while in many species the thallus surface mirrors inflated bark. Most taxa, however, grow on flaking bark with only ascomata protruding out of the thallus.

The ascomatal features and chemical substances play a vital role in differentiating the different thelotremoid groups. Based on morphology, the ascomata may be of the chroodiscoid, fissurinoid, leprocarpoid, platycarpoid, lamelloid, scabioid, or topeliopsoid types. However, except for *C. platycarpa* and *C. recurva*, all Indian specimens lack secondary compounds.

Sixteen species of *Chapsa* are currently known from India. The evergreen forests in the Western Ghats represented by nine species was the most diverse, with six species known from the tropical rain forests of the eastern Himalayas and four species known from the Andaman and Nicobar Islands. One report of *Chapsa dilatata* (Müll. Arg.) Kalb from Arunachal Pradesh (Dubey et al. 2008, as *Thelotrema dilatatum*) was based on a misdetermined specimen that represents a *Myriotrema* species. All accurately identified *Chapsa* species recorded from India are presented here with brief descriptions.

Materials & methods

Material preserved in the herbarium of the National Botanical Research Institute (LWG) was examined morphologically, anatomically, and chemically. Thin hand-cut sections of apothecia and thallus mounted in tap water, cotton blue, 5% KOH, and iodine solution were observed under a compound microscope (LEICA DM 500). Chemical spot tests and TLC (using solvent system A) were conducted according to Orange et al. (2001).

Taxonomic descriptions

Chapsa alborosella (Nyl.) Frisch, Biblioth. Lichenol. 92: 90, 2006.

The species is characterized by an ecorticate, pale olive green thallus lacking lichen compounds, round to angular or shortly elongate pale brown apothecia level with the thallus, 8-spored asci and hyaline, transversely septate, fusiform to clavate or oblong, I– ascospores.

Chapsa platycarpella differs from the closely related *C. alborosella* in having a corticate thallus and a pale to blackish apothecial disc. Patwardhan & Kulkarni (1977a) and Nagarkar et al. (1988) reported this species from south India as *Ocellularia alborosella*. The species is common in tropical evergreen forest of Kerala in the Western Ghats.

"*Chapsa hiata*" (Hale), **ined.**

Known from evergreen forests in the southern part of India, this species is well characterized by an ecorticate thallus lacking lichen substances, wide and open apothecia with recurved margins, free proper exciple, 4–8-spored asci, and small hyaline muriform I– ascospores measuring 14–16 × 4–7µm.

Patwardhan et al. (1985) reported it from Karnataka as *Thelotrema hiatum*. Similar to *Chapsa leprocarpoides*, *C. velata* and *C. pseudophlyctis* in lacking thallus compounds, the species differs in having small ascospores. The latter two species also differ in having a fused proper exciple.

Chapsa indica A. Massal., Atti I. R. Ist. Veneto Sci. Lett. Arti, Ser. 3, 5: 257, 1860.

This taxon is characterised by an ecorticate brownish-white to olive-grey thallus lacking lichen compounds, rounded to angular or shortly elongated and slightly branched apothecia that are level with the thallus, 6–8-spored asci, and hyaline transversely septate oblong-fusiform ascospores.

Patwardhan & Nagarkar (1980) and Nagarkar et al. (1988) first reported the species from India (as *Ocellularia pycnophragmia* (Nyl.) Zahlbr.) from tropical rain forests of Andaman and Nicobar, Assam, and Meghalaya. Similar in having an ecorticate whitish (-brownish) to olive-grey thallus, *C. leprocarpa* and *C. pseudophlyctis* differ from *C. indica* in having muriform ascospores.

Chapsa laceratula (Müll. Arg.) Rivas Plata & Lücking, Lichenologist 42: 183, 2010.

The species exhibits a pale to dark olive-green to olive brown, corticate surface lacking secondary metabolites, round to irregular, perithecioid to apothecioid apothecia with lacerate margins, 1–2(–4)-spored asci, and hyaline, muriform, fusiform ascospores.

Patwardhan & Kulkarni (1977a) reported *Chapsa laceratula* (as *Thelotrema laceratulum*) from Karnataka, Kerala, Maharashtra, and Tamil Nadu in southern India. The scabioid apothecia with vertically layered excipulum and

≤4-spored asci are the major distinguishing characters of *C. laceratula*, which morphologically may be confused with *Topeliopsis* species. It is generally distributed at lower elevation and growing luxuriantly in evergreen forests of Western Ghats.

Specimens examined: **INDIA. Karnataka:** Central Western Ghat, Shimoga district, 3 km before Agumbe Ghat, from Koppa to Agumbe, alt. 649 m, on bark in evergreen forest, 14.01.2008, H.T. Lumbsch, D.K. Upreti, P.K. Divakar & J. Tandon 19730M/A (LWG); Uttarkannad, Sharavathi Ghat, near Gersoppa, alt. 718 m, on bark in evergreen forest, 16.01.2008, H.T. Lumbsch, D.K. Upreti, P.K. Divakar & J. Tandon 19744A-1, 19744B, 1944C-2, 19744I, 19745, 19745A-3, 19745C (LWG); **Tamil Nadu**: Madurai district, High ways Vattapara (Meghamali), alt. 1580 m, on fallen twigs, 22.03.1999, S. Nayaka 92(LWG).

Chapsa leprieurii (Mont.) Frisch, Biblioth. Lichenol. 92: 105, 2006.

The species is characterized by a brown-olive, cartilaginous thallus lacking secondary compounds, rather small, rounded to slightly elongated or branched apothecia level with the thallus, 8-spored asci, and transversely septate brown oblong to ellipsoidal or clavate ascospores.

Chapsa leprieurii has been reported from Karnataka, Kerala, and Tamil Nadu in southern India (Awasthi 1991, as *Thelotrema leprieurii*; Singh & Sinha 2010, as *T. leprieurii*). The brown-spored similar species, *C. platycarpa*, differs in producing lichen compounds and a double margin.

Chapsa leprocarpa (Nyl.) Frisch, Biblioth. Lichenol. 92: 108, 2006.

The taxon exhibits a pale to dark olive-grey thallus lacking lichen compounds, large chroodiscoid apothecia with a lobed and recurved margin, pale brown to blackish but heavily white pruinose disc, 1-spored asci, and muriform ascospores.

Awasthi (1991) first recorded *C. leprocarpa* (as *Thelotrema colobicum*) from Andaman and Nicobar Islands. *Chapsa leprocarpa* inhabits lowland and submontane regions in the Western Ghats.

Specimens examined: **INDIA. Kerala:** Idukki district, I.C.R.I. campus, Myladumpara, alt. ca. 1200 m, on bark of tree, 01.03.1984, D.D. Awasthi & G. Awasthi 84.88 (LWG-LWU); on way Myladumpara to Munnar, Santhampara area, alt. ca. 1200 m, on bark of tree, 02.03.1984, D.D. Awasthi & G. Awasthi 84.179 (LWG-LWU); Thikkady, Periyar Tiger Reserve, Sakunthalakadu, on bark, 23.03.2006, B. Haridas 06–009615/B (LWG).

Chapsa leprocarpoides (Hale) Cáceres & Lücking, Libri Bot. 22: 52, 2007.

The species is ecorticate, pale olive to fawn coloured, lacking lichen substances, without compact surface, usually reflecting bark through the matted thallus surface; it has immersed to semi-immersed, rounded to angular apothecia with a flesh-coloured pruinose disc and low jagged to lobed margins, a pale to brownish or hyaline free proper exciple, 8-spored asci, and hyaline muriform ellipsoidal to oval ascospores.

Chapsa leprocarpoides was collected from evergreen tropical forests of Karnataka on rough tree barks at lower altitude. The ecorticate "*Chapsa hiata*" differs in having rather small ascospores while *C. velata* and *C. pseudophlyctis* have comparatively larger ascospores and a fused proper exciple.

Specimens examined: **INDIA. Karnataka:** Chikmagalure district, Chamudi Ghat, Kuvettu, alt. 104 m, on bark in evergreen forest, 15.01.2008, H.T. Lumbsch, D.K. Upreti, P.K. Divakar & J. Tandon 19739R; Uttar Kannad, Sharavati Ghat, near Gersoppa, alt. 718 m, on bark in evergreen forest, 16.01.2008, H.T. Lumbsch, D.K. Upreti, P.K. Divakar & J. Tandon 19744J (LWG); Shimoga district, Sagar to Talguppa, Ulanahalli, alt. 697 m, on bark in evergreen forest, 16.01.2008, H.T. Lumbsch, D.K. Upreti, P.K. Divakar & J. Tandon 19742E, 19742E-1(LWG); Central Western Ghat, Shimoga district, near Jog fall, Kargal, alt. 644 m, 16.01.2008, H.T. Lumbsch, D.K. Upreti, P.K. Divakar & J. Tandon 19742B-2, 19743O-1 (LWG).

Chapsa meghalayensis (Patw. & Nagarkar) Lumbsch & Divakar, Lichenologist 42: 183, 2010.

This taxon is characterized by its ashy-white, ecorticate, granular thallus lacking lichen compounds, immersed and chroodiscoid apothecia with recurved margins, lacerate exciple, 2-spored asci, and small muriform brown ascospores measuring 27–46 × 11–16 µm.

First described from Meghalaya by Patwardhan & Nagarkar (1980) as *Leptotrema meghalayense,* the species was later transferred to *Myriotrema* by Awasthi (1991). *Chapsa meghalayensis* is endemic to India and collected from evergreen forests of northeast India.

Chapsa patens (Nyl.) Frisch, Biblioth. Lichenol. 92: 111, 2006. Pl. 1a

Thallus corticolous, epiperidermal, ecorticate, dark olivaceous grey to dark grey or blackish, continuous, ± cracked due to bark texture, uneven, bark reflecting through thallus. Prothallus indistinct. Photobiont layer well developed, up to 50 µm thick. Medulla endoperidermal. Apothecia scattered, sometimes grouped in two, immersed to level with thallus, mostly rounded to slightly angular or irregular in shape, up to 2.0 mm in diam. Margin raised, lobed to ± continuous, mostly straight to recurved later, brownish to faintly crystalline pruinose inner side. Disc reddish-brown, exposed, covered by thick pruina. Proper exciple cupular, pale to hyaline, sometimes brownish, up to 40–80 µm thick laterally. Periphysoides indistinct to 30 µm long, inclined towards epihymenium. Epihymenium 10–15 µm high, slightly brownish, granular. Hymenium, clear, 130–140 µm high. Paraphyses entangled, simple, ≤1.5 µm thick, apically thickened, ± dendroid branched, adspersed with grayish granules. Ascus, 1-spored, clavate, 90–130 × 25–40 µm. Ascospores hyaline, densely muriform, with rounded ends, 80–125 × 20–35 µm, I–.

Chemistry: K–, PD–, C–; no lichen compound detected in TLC.

Ecology & distribution: The species is a new record to India reported from tropical rain forests of the Eastern Himalayas where it is common in open,

canopied old forests with large tree trunks and generally found at 1700–2500 m. Widely distributed and reported from Africa, Japan, and Sri Lanka.

Specimen examined: **INDIA. West Bengal:** Eastern Himalaya, Darjeeling district, Tiger hill, north face of the hill, alt. ca. 2500 m, on bark of tree, 05.03.1967, D.D. Awasthi & M.R. Agarwal 67.21 (LWG-LWU).

Remarks: *Chapsa leprocarpa,* which also lacks lichen substances, differs from *C. patens* in having a slightly lower hymenium and smaller ascospores and grows at lower altitudes (1000–1200 m). The Indian specimen of *C. patens* exhibits a dirty grey to dark olivaceous thallus colour hardly distinguished from the bark, while *C. leprocarpa* has a pale-green to slightly greyish-green epiperidermal thallus. However, the hymenium and ascospores of the Indian sample are intermediate in size and closer to *C. patens* than *C. leprocarpa* and its distribution and thallus and apothecial morphology also agree well with the diagnostic features of *C. patens*. Hale (1981) and Matsumoto (2000) both described *C. patens* as a stictic acid-producing species that after re-investigation were shown to lack these substances. The records from Japan and Sri Lanka should be re-examined (Frisch et al. 2006).

Chapsa platycarpa (Tuck.) Frisch, Biblioth. Lichenol. 92: 113, 2006.

The species is recognized by the dark olive-green to olive-brown or pale yellowish-brown thallus containing the stictic acid chemosyndrome, a rounded to slightly irregular apothecioid to chroodiscoid shape in older material, erumpent apothecia with double margins, 8-spored asci, and transversely septate ellipsoidal to fusiform brown ascospores.

Earlier placed in the neglected genus *Phaeotrema* due to its transversely septate brown ascospores, *Chapsa platycarpa* was reported from India (Kerala) as *P. platycarpum* (Patwardhan & Kulkarni 1977a). The similar *C. leprieurii* lacks stictic acid as a major thallus compound.

Chapsa platycarpella (Vain.) Frisch, Biblioth. Lichenol. 92: 118, 2006. Pl. 1b

Thallus corticolous, endoperidermal, olive-green to pale-green, continuous, shiny, compact, cartilaginous, uneven to warty. Prothallus indistinct to brownish. Medulla white, indistinct, endoperidermal. Phenocortex well developed, dense, 20–30 µm thick. Photobiont layer 20–35 µm thick, with inclusion of calcium oxalate crystals, largely endoperidermal. Apothecia scattered to aggregate in groups, immersed to level with thallus, round to mostly angular or irregular in shape, ≤1.0 mm in diam. Margin thin, fissured to lobed, recurved, and yellowish to fawn with felty white pruinose to crystalline inner surface. Disc pale to blackish, distinctly white pruinose. Proper exciple cupular, pale to hyaline, 6–10 µm wide. Periphysoides indistinct to 25 µm long, inclined towards epihymenium. Epihymenium 5–8 µm high, granular, unpigmented

to crystalline. Hymenium clear, 55–95 µm high. Paraphyses simple, straight, ≤2.0 µm thick, tips agglutinate with fine greyish to brownish granules. Ascus 8-spored, clavate, 45–90 × 6–9 µm. Ascospores, hyaline, transversely 3–5 septate, fusiform with acute end cells, 12–16 × 3–5 µm, I–.

Chemistry: K–, PD–, C–; no lichen compounds detected in TLC.

Ecology & distribution: Known to grow on smooth bark of young trees in lowland rainforests and coastal forests in shade as well as on exposed surfaces. In India, reported on trees in evergreen tropical forest in Kerala.

Specimen examined: **INDIA. Kerala:** Idukki, Adimali Forest Range, Thondi Kappu, on *Myristica beddomei*, 15.02.2006, B. Haridas 06–009598(LWG).

Remarks: *Chapsa platycarpella,* which is considered a separate species by Frisch et al. (2006), is otherwise treated as a synonym of *C. alborosella*. The species is well characterized and separated from the latter in having a cartilaginous thallus, thick phenocortex, and loosely aggregated apothecia with blackish discs covered by bluish-white pruina.

Recently, Rivas Plata et al. (2010) placed the species in synonymy with *C. astroidea* (Berk. & Broome) Cáceres & Lücking; however following Frisch (2006) with adequate distinguishing characteristics the species is accepted here as a new record for India.

Chapsa pseudoexanthismocarpa (Patw. & C.R. Kulk.) Rivas Plata & Lücking, Lichenologist 42: 183, 2010.

The taxon is characterized by a pale yellowish to greenish brown or pale olive thallus lacking secondary compounds, apothecia that are rounded to somewhat irregular and sometimes perithecioid, erumpent, immerged to distinctly emergent, 4–8-spored asci, and hyaline transversely septate bacilliform-fusiform ascospores.

Patwardhan & Kulkarni (1977b) described the species from southern India (Kerala) in *Ocellularia*. Larger ascospores readily distinguish *C. pseudoexanthismocarpa* from *C. indica*. Other characters include the rough epiperidermal thallus, lepadinoid apothecia, and lacerate exciple.

Chapsa pseudophlyctis (Nyl.) Frisch, Biblioth. Lichenol. 92: 120, 2006.

The species is characterized by its white to whitish, whitish-grey to pale-grey thallus lacking secondary compounds, round to angular apothecia with jagged, often eroded margins having a white crystalline inner surface, 1–6-spored asci, and hyaline muriform ascospores.

Chapsa pseudophlyctis may sometimes be confused with *C. leprocarpa,* which can be distinguished by asci consistently bearing a single larger ascospore. Jagadeesh Ram & Sinha (2009) first reported *C. pseudophlyctis* as new to India from Meghalaya and Sikkim.

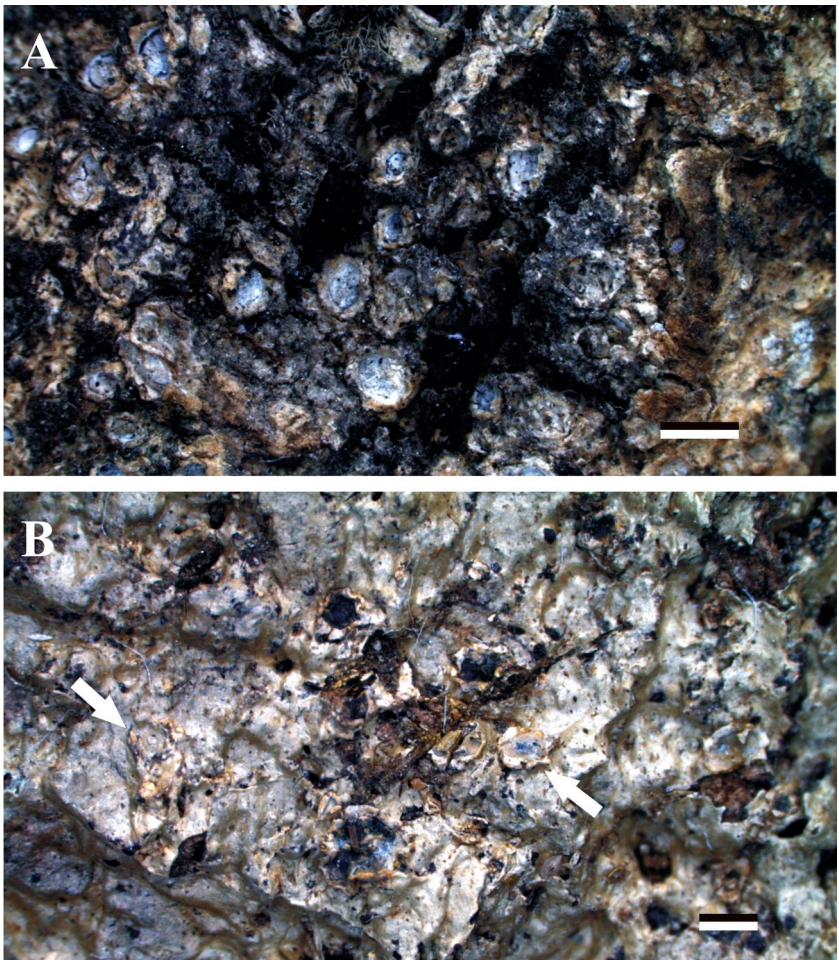

Plate. 1. New records of *Chapsa* from India.
A. *Chapsa patens*. B. *Chapsa platycarpella* (note the apothecia).
Scale bars: A = 2 mm; B = 1 mm.

Chapsa recurva (G. Salisb.) Frisch, Biblioth. Lichenol. 92: 95, 2006.

Chapsa recurva and *C. platycarpa* are the only two *Chapsa* species that produce stictic acid as a major secondary compound (Rivas Plata et al. 2010). Nagarkar et al. (1986) reported the species (as *Thelotrema recurvum*) from Andaman & Nicobar Islands, but noted the absence of secondary compounds. Other major distinguishing characters include the corticate whitish grey smooth thallus, numerous solitary round to elongated semi-emergent chroodiscoid apothecia, and hyaline muriform ascospores.

"*Chapsa stellata*" (Hale), **ined.**

The taxon is recognized by the greenish, glaucous, continuous, mostly epiperidermal thallus lacking lichen substances, dispersed, slightly immersed chroodiscoid apothecia having a white pruinose disc and recurved margins, a ± fused brown proper exciple, 1-spored asci, and ellipsoidal olivaceous to brownish muriform ascospores, 88–135 × 22–30 µm. Patwardhan & Nagarkar (1980) reported the species (as *Leptotrema stellatum*) from Meghalaya in the eastern Himalayas.

Chapsa velata (Nyl.) Cáceres & Lücking, Libri Bot. 22: 54, 2007.

The species is characterized by the ashy-white smooth partly hypophloeodal thallus lacking lichen substances, semi-emergent chroodiscoid apothecia with erect to recurved margins, fused to free brown proper exciple, hyaline hymenium, 4–8-spored asci (1–2-spored according to Patwardhan & Nagarkar 1980), and hyaline ellipsoidal muriform ascospores. The species was recorded from the Andaman Islands (Awasthi 1991, as *Thelotrema velatum*) and Nagaland (Patwardhan & Nagarkar 1980, as *T. velatum*).

Key to *Chapsa* species recorded from India

1a. Ascospores transversely septate 2
1b. Ascospores (sub-) muriform 7

2a. Ascospores hyaline 3
2b. Ascospores brown 6

3a. Ascospores > 40 µm 4
3b. Ascospores < 40 µm 5

4a. Ascospores (40–) 70–120 µm long ..... ***C. indica***
4b. Ascospores 100–200 µm long ..... ***C. pseudoexanthismocarpa***

5a. Ascospores 12–16 µm long, 4–6-septate, corticate ..... ***C. platycarpella***
5b. Ascospores 17–22 µm long, 5–9-septate, ecorticate ..... ***C. alborosella***

6a. Stictic acid present, proper exciple free (double margin), apothecial disc grey-brown ..... ***C. platycarpa***

6b. Lichen substances absent, proper exciple fused, disc pale brown to greyish ..... ***C. leprieurii***

7a. Ascospores hyaline 8
7b. Ascospores brown 5

8a. Ascospores ≤60 µm long 9
8b. Ascospores > 60 µm long 13

9a. Ascospores 12–15 µm long, lichen substances absent ..... ***"C. hiata"***
9b. Ascospores >15 µm long, chemistry variable 10

10a. Stictic acid present ..... ***C. recurva***
10b. Lichen substances absent 11

11a. Proper exciple free, apothecia often aggregate, ascospores 30–40 × 10– 12 µm ..... ***C. leprocarpoides***
11b. Proper exciple fused apothecia solitary, ascospores 30–60 × 12–20 µm 12

12a. Thallus ashy-white, apothecial disc dark-grey, thinly pruinose with bluish tinge .....***C. velata***
12b. Thallus pale-olive, apothecial disc pale brown, distinctly white pruinose ..... ***C. pseudophlyctis***

13a. Thallus with prosoplectenchymatous cortex, proper exciple layered ***C. laceratula***
13b. Thallus ecorticate 14

14a. Ascospores ≤125 µm long ..... ***C. patens***
14b. Ascospores ≤90 µm long .....***C. leprocarpa***

15a. Ascospores 27–46 × 11–16 µm ..... ***C. meghalayensis***
15b. Ascospores 88–135 × 22–30 µm ..... ***"C. stellata"***

Acknowledgements

We are grateful to the Director of the CSIR-National Botanical Research Institute, Lucknow, for providing necessary facilities, and the Ministry of Environment and Forests, New Delhi, for financial support. The authors are also grateful to Dr. R. Lücking and Dr. Pradeep. K. Divakar for their valuable comments on manuscript.

Literature cited

Awasthi DD. 1991. A key to microlichens of India, Nepal and Sri Lanka. Bibliotheca Lichenologica 40: 1–337.

Awasthi DD. 2000. Lichenology in Indian subcontinent: a supplement to "A Handbook of Lichens". Bishen Singh Mahendra Pal Singh, DehraDun, India.

Dubey U, Upreti DK, Rout J. 2007. Lichen flora of Along town, West Siang district, Arunachal Pradesh. Phytotaxonomy 7: 21–26.

Frisch A, Kalb K, Grube M. 2006. Contribution towards a new systematic of the lichen family *Thelotremataceae*. Bibliotheca Lichenologica 92: 1–556.

Hale ME. 1974. Morden-Smithsonian Expedition to Dominica: the lichens (*Thelotremataceae*). Smithsonian Contributions to Botany 16: 1–46.

Hale ME. 1978. A revision of the lichen family *Thelotremataceae* in Panama. Smithsonian Contributions to Botany 38: 1–60.

Hale ME. 1981. A revision of the lichen family *Thelotremataceae* in Sri Lanka. Bulletin of the British Museum (Natural History), Botany Series 8: 227–332.

Jagadeesh Ram TM, Sinha GP. 2009. New records of lichenized and non-lichenized ascomycetes from India. Indian Journal of Forestry 32(4): 635–640.

Mangold A, Martin, PM, Lücking, R, Lumbsch TH. 2008. Molecular phylogeny suggests synonymy of *Thelotremataceae* within *Graphidaceae* (*Ascomycota: Ostropales*). Taxon 57: 1–11.

Mangold A, Elix JA, Lumbsch HT. 2009. *Thelotremataceae*. Flora of Australia 57: 195–420.

Matsumoto T. 2000. Taxonomic studies of the *Thelotremataceae* (*Graphidales*, lichenized *Ascomycota*) in Japan (1) Genus *Thelotrema*. J. Hattori Bot. Lab. 88: 1–50.

Nagarkar MB, Sethy PK, Patwardhan PG. 1986. Materials for a lichen flora of the Andaman Islands – I. Mycotaxon 27: 71–82.

Nagarkar MB, Sethy PK, Patwardhan PG. 1988. Lichen genus *Ocellularia* (Family *Thelotremataceae*) from India. Biovigyanam 14: 24–43.

Orange A, James PW, White FJ. 2001. Microchemical methods for the identification of lichens. British Lichen Society.

Patwardhan PG, Kulkarni CR. 1977a. A contribution to our knowledge of the lichen flora of India I: Family *Thelotremataceae*. Kavaka 5: 1–17.

Patwardhan PG, Kulkarni CR. 1977b. Some new taxa of the family *Thelotremataceae* from Western Ghats, SW India. Norwegian Journal of Botany 24: 127–131.

Patwardhan PG, Nagarkar MB. 1980. Notes on some lichens from northeast India II: family *Thelotremataceae*. Biovigyanam 6: 1–10.

Patwardhan PG, Sethy PK, Nagarkar MB. 1985. A contribution to our knowledge of the lichen family *Thelotremataceae* from South India. Biovigyanam 11: 133–140.

Purvis OW, Jørgensen PM, James PW. 1995. The lichen genus *Thelotrema* Ach. in Europe. Bibliotheca Lichenologica 58: 335–360.

Rivas Plata E, Lücking R, Lumbsch HT. 2008. When family matters: an analysis of *Thelotremataceae* (lichenized *Ascomycota: Ostropales*) as bioindicators of ecological continuity in tropical forests. Biodiversity and Conservation 17: 1319–1351. http://dx.doi.org/10.1007/s10531-007-9289-9

Rivas Plata E, Lücking R, Sipman HJM, Mangold A, Kalb K, Lumbsch HT. 2010. A world-wide key to the thelotremoid *Graphidaceae*, excluding the *Ocellularia-Myriotrema-Stegobolous* clade. The Lichenologist 42(2): 139–185. http://dx.doi.org/10.1017/S0024282909990491

Santesson R. 1952. Foliicolous lichens I. A revision of the taxonomy of the obligately foliicolous, lichenized fungi. Symbolae Botanicae Upsalienses 12: 1–590.

Singh KP, Sinha GP. 2010. Indian lichens: An annotated checklist. Botanical Survey of India. Shiva Offset Press, DehraDun, Uttarakhand.

Sipman HJM, Harris RC. 1989. Lichens. 303–309, in: H Lieth, MJA Were (eds). Tropical Rain Forest Ecosystems. Amsterdam: Elsevier Science Publishers.